Outlook on northeast monsoon rainfall of Tamil Nadu

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सार — तिरुअनंतपुरम तथा मद्रास के ऊपर अगस्त और सितम्बर महीनों के लिये 850,500 एवं 150 एच पी ए स्तरों पर माध्य मासिक पवन सदिशों की क्रमवार जांच की गई है । इसका लक्ष्य अक्तूबर के आरंभ में तमिलनाडु में उत्तर-पूर्वी मानसून वर्षा की संभावना को व्यक्त करने के लिये एक सक्षम योजना का विकास करना है । छह पूर्व सूचकों के लिये बहु समाश्रयण योजना की पहचान की गई है । योजना के 28 वर्षों के विकसित आंकड़ों का जब स्वतंत्र रूप से पांच वर्षों की अवधि में परीक्षण किया गया तो अच्छे परिणाम निकले ।

ABSTRACT. The mean monthly wind vectors at 850, 500 and 150 hPa levels over Thiruvananthapuram (TRV) and Madras (MDS) for August and September have been subjected to stepwise screening. The objective is to develop a scheme capable of providing an outlook of northeast monsoon rainfall of Tamil Naou in the beginning of October. A multiple regression scheme of six predictors has been identified. The scheme developed from 28-year data performed well when tested in an independent five-year period.

Key words — Northeast monsoon, Multiple regression scheme, Regression coefficient.

1. Introduction

Northeast monsoon season (October-December) is the main rainy season of the State of Tamil Nadu. It accounts for about 47% of the annual rainfall of 101 cm of Tamil Nadu. The coefficient of variation of rainfall is 27% which testifies to the fairly large interannual variation of rainfall. This emphasises the importance of advance prediction of the quantum of northeast monsoon rain. Doraiswamy Iyer (1941) and Raj (1989) (the latter one will be henceforth referred as I) made some attempts for foreshadowing the northeast monsoon rainfall of Tamil Nadu. In 'I' mean monthly wind vectors at various isobaric levels of several stations of India for June-September were correlated with the subsequent October-December rainfall of Tamil Nadu and some parameters which had predictive value were identified, based on the data available up to 1983. The techique used was simple linear regression. The constraints involved in developing multiple regression equations where mainly the non-availability of the data for some years for almost every predictor. However, such constraints could be overcome by proper application of statistical techniques.

The predictors identified in 'I' are : Jodhpur September 100 hPa meridional, Nagpur September 100 hPa zonal, and Thiruvananthapuram August-September 150 hPa zonal wind components. The last parameter proved to be most promising predictor and exhibited a fairly high correlation coefficient (CC) of 0.77. The other two parameters identified were based on small samples only. Indian northeast monsoon, esentially being a sub-regional phenomenon, with Tamil Nadu its major beneficiary flanked between two radio wind stations, *viz.*, Madras (MDS) in the north and Thiruvananthapuram (TRV) in the south, a

thorough screening of the upper winds of these two stations during August-September, to evolve a multiple regression scheme appeared to be a worthwhile exercise.

2. Data

The mean monthly winds at MDS and TRV for three levels 850, 500 and 150 hPa (representing lower, middle and upper troposphere) for the months of August & September were collected for the 33-year period 1958-1990. Upper wind data for higher levels for the above stations are available from 1958 only. Data for 1958-1964 and 1983-1990 were extracted from the publication *'Monthly Climatic Data for the World'*; for 1965-1982 data were obtained from National Data Centre, Meteorological Office, Pune. The data were thoroughly scrutinized and in case of doubtful data, the veracity was checked and the correctness corroborated from an alternative source (such as departmental records, daily weather charts etc). The rainfall data of Tamil Nadu for 1958-1990 were obtained from the Hydrometeorological Section, Meteorological Office, Pune. The 28-year period 1958-1985 was kept as the developmental period and subseqent 5-year period 1986-1990 as the test period.

Whereas upper wind data were available for every year for August and September at 850 and 500 hPa levels, they were missing for 150 hPa level for some years. Table 1 lists such years. As presence of missing data points in a multiple regression scheme will cause complications, the gaps were filled up by making use of intercorrelation between TRV and MDS wind vectors. The winds were resolved into their zonal and meridional components and the CCs based on developmental sample were computed between the MDS and TRV series, *e.g.*,

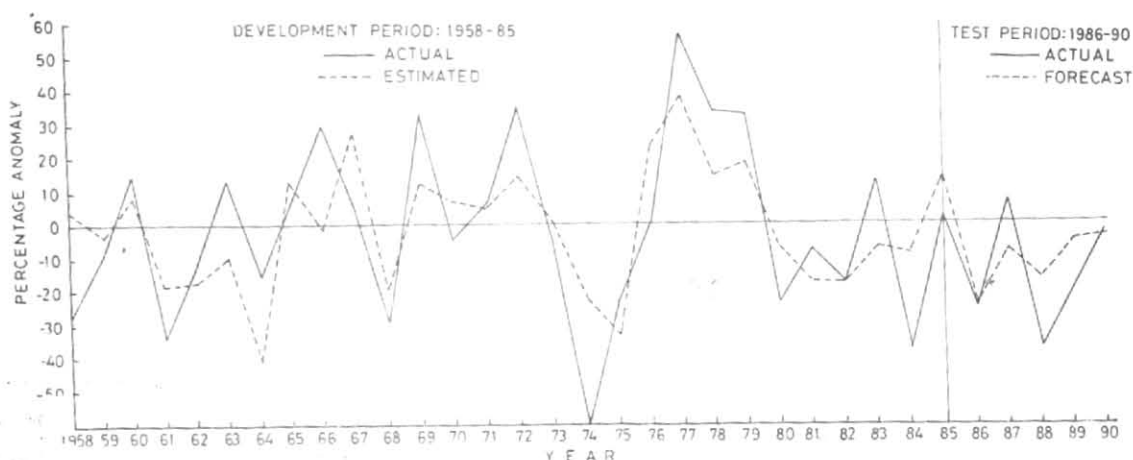*Present affiliation : Regional Meteorological Centre, Madras.

Fig. 1. Observed and estimated forecast (based on multiple regression scheme) rainfall of northeast monsoon of Tamil Nadu

MDS, August 150 hPa zonal wind data were correlated with those of TRV, August 150 hPa zonal wind. Four CCs thus resulted which were all positive, varied between 0.40 and 0.59 and significant at 5% level. The regression equations were constructed and the missing values estimated. It could be seen that for August 1960 data were missing for both TRV and MDS and so normal values were substituted. A complete data set of August and September zonal and meridional winds for TRV and MDS at 850, 500 and 150 hPa levels for 1958-1990 was thus obtained.

3. Analysis of data

3.1. From the resolved series of zonal and meridional components of winds the mean of August and September values was computed and another series for August-September got generated. Similarly, computations of mean of TRV and MDS resulted in another set of series. Thus a total of 54 series resulted (stations, TRV, MDS, TRV & MDS for months August, September, August-September at 850, 500, 150 hPa zonal meridional winds for 1958-1990).

3.2. In a multiple regression scheme, the direct CC between the potential predictor and the predictand (here October-December Tamil Nadu rainfall) need not always be the dominant factor. Even a potential predictor with a (direct) CC of zero could find a place in such scheme. This aspect has been lucidly explained by Kendall and Stuart (1968). Generally the predictors are selected by the so called 'stepwise forward screening' (WMO 1966).

3.3. It is quite obvious that for the series stated above is to be used in a stepwise screening scheme, August & September series could be combined, TRV and MDS series could be combined but not August with August-September or TRV with TRV & MDS mean. The possible combinations for screening are presented in Table 2, which are 16. The number of predictors available for each set is also indicated. For example TRV — August has 6 predictors, *viz.*, the zonal and meridional winds at the three levels chosen; whereas TRV & MDS— August & September has 24 predictors which are TRV — August 6, TRV — September 6, MDS — August 6, MDS — September 6, thus a total of 24.

3.4. Each of the 16 sets of possible predictors was subjected to stepwise screening using the developmental period data only. After the choice of the first predictor the next parameter which corresponded to the largest additional variance explained was chosen as the second predictor and the sequence was continued till the extra variance explained was insignificant at 1% level or when the number of predictors selected reached 8. The multiple CC, standard error, regression coefficients, partial CCs were also computed. Based on the regression equation the performance of the various schemes selected was tested in the independent sample based on the data of 1986-1990 and the results were critically evaluated.

3.5. It was found that the sets based on August-September (*i.e.*, mean of August and September) predictors were more reliable. Some systems yielded very high multiple CCs of up to 0.88 but completely broke down during the test period. Some systems yielded very low CCs and had to be discarded. There was only one system which yielded reasonably high CC and performed well in both the samples. This system had six predictors which are : TRV zonal 850, 500 and 150 hPa, TRV meridional 150 hPa and MDS zonal 850 and 500 hPa winds, all for August-September. The system yielded a multiple CC of 0.70 explaining 48.5% of the total variance with a standard error of estimate as 18%. The results of screening and other details are presented in Table 3. The performance of the regression equation has been presented in Fig. 1. In the test period of 1986-1990, the system has correctly predicted the deficiency of rainfall in 1986 and 1988. The maximum error is 20.4% only and the mean error during 1986-1990 is only 10.5%, much less than the standard error of 18% suggested by the system. Since 1980 the October-December rainfall of Tamil Nadu has generally been below normal and the estimated/forecast values during 1981-1990 have been by and large consistent with this feature also.

The first predictor chosen which is the TRV August-September zonal 150 hPa wind, had a CC of 0.48 with the predictand. This parameter was identified as a leading parameter in I. Though the fairly high CC obtained in I (0.77 during 1957-1980, based on 17-year data) has not prevailed, the difference is within the sampling limits.

TABLE 1

Years with no data for 150 hPa level

Month	TRV	MDS
August	1960	1959,60,62,63
September	1960,61	1962

TABLE 2

Various series available for screening and No. of predictors available against each series

Month	Station			
	TRV	MDS	TRV & MDS (Combined)	TRV & MDS (Mean)
Aug	6	6	12	6
Sep	6	6	12	6
Aug & Sep combined	12	12	24	12
Aug & Sep mean	6	6	12	6

TABLE 3

Multiple regression scheme

Predictor	Variance explained	Regression coefficient	Mean value of the predictor (in mps)
TRV ZO 150 hPa TZ1	23.4	5.4	—29.2
TRV ZO 500 hPa TZ5	11.7	11.5	1.9
MDS ZO 500 hPa MZ5	6.2	—11.4	2.6
MDS ZO 850 hPa MZ8	3.4	10.8	6.3
TRV ZO 850 hPa TZ8	2.3	—8.4	9.2
TRV ME 150 hPa TM1	1.5	—2.0	—4.4
Total variance	48.5		
Constant term of the regression equation		164.1	

(Note : All the predictors are based on Aug-Sep data)

4. Interpretation of the regression equation in meteorological terms

The multiple regression equation of Table 3 can be written as (notation as in Table 3) :

Rainfall (expressed as percentage departure from normal)

$$= 5.4\,(TZ1 + 29.2) + 11.5(TZ5 - 1.9) - 11.4(MZ5$$

$$- 2.6) + 10.8\,(MZ8 - 6.3) - 8.4(TZ8 - 9.2)$$

$$- 2.0(TM1 + 4.4).$$

$$= 5.4\,TZ1 + 11.5\,TZ5 - 11.4\,MZ5 + 10.8\,MZ8$$
$$- 8.4\,TZ8 - 2.0\,TM1 + 164.1.$$

Each term of the above equation is individually positive if :

(i) TRV zonal 150 hPa (easterly) wind is weaker (than normal),

(ii) TRV zonal 500 hPa wind is stronger,

(iii) MDS zonal 500 hPa wind is weaker,

(iv) MDS zonal 850 hPa wind is stronger,

(v) TRV zonal 850 hPa wind is weaker, and

(vi) TRV meridional 150 hPa (northerly) wind is stronger.

From the mean values computed and presented in Table 3, we find that the (normal) vorticity generated by the zonal wind in the region TRV-MDS is positive at 850 hPa. Thus (iv) and (v) would correspond to a negative anomaly of zonal vorticity, being generated in TRV-MDS at 850 hPa. At 500 hPa, however, the normal vorticity in the same region is negative and (ii) and (iii) correspond to higher amount of generation of negative vorticity. Condition (i) corresponds to disintegration of easterly jet stream over the extreme south Peninsula during the latter half of summer monsoon. This feature was touched up in I also. Condition (vi) occurs when there is higher northerly component in the easterly jet stream. Conditions (i)-(vi) correspond to positive departure of rainfall. The complements of (i)-(vi) will correspond to negative departures and can be similarly interpreted.

5. Conclusion and discussion

The system identified, based on the six predictors selected by screening regression could be used to obtain an outlook on northeast monsoon rainfall of Tamil Nadu at the beginning of the season. As in every such scheme, the correlation coefficients do change with time and so the equation may require the periodic updating.

References

Doraiswamy Iyer, V., 1941, India Met. Dep. Sci. Notes, **8**, 98.

Kendall, M.G. and Stuart, A., 1968, *The Advanced Theory of Statistics Griffin*, London, Vol. II, pp. 278-374.

Raj, Y.E.A., 1989, Statistical relations between winter monsoon rainfall and the preceding summer monsoon," *Mausam*, **40**, 1, pp. 51-56.

WMO, 1966, Statistical Analysis and Prognosis in Meteorology, Tech. Note No. 71.